

Enabling Integration of Distributed Renewables - Program 174

Program Overview

Program Description

The integration of distributed renewable generation sources into the electricity grid poses a number of challenges for the industry. Utilities will be faced with issues of enabling high penetration of distributed generation into both existing and future distribution systems. This program will address these issues with a variety of projects that cover interface devices, analytics, system studies, special applications and assessment of new technology for effective interconnection and integration of renewable and other distributed generation. The program also includes lab and field tests, demonstrations, and use-case reference library. A primary objective is to expand utility hands-on knowledge and capability to use, leverage, and monetize the value of renewable generation deployments without reducing distribution safety, reliability, or asset utilization effectiveness. A second focus is to evaluate end-user level intertie equipment both grid-tied and direct photovoltaic (PV) energy-to-appliance applications.

Research Value

With the knowledge acquired through this research program, program members will have access to information that can help them in these ways:

- Maintaining distribution network reliability and safety
- Strategies for responding to customer-sited renewable generation
- New business models, economic analysis of ownership options and potential to rate base distributed assets
- Proactive response to state and federal renewable portfolio standards (RPS)
- Planning for renewable deployment and advanced distribution automation
- Utilizing the value of the utility distribution system to support renewable distributed generation

Approach

- This was a new program in 2009, and will build on previous work related to distributed resource integration. It will also utilize EPRI experience with the advanced distribution automation, Green Circuits, and Intelligrid programs, as well as the smart grid demonstrations.

Accomplishments

The integration of renewables program has delivered valuable information that has helped its members and the industry. Some examples include:

- Members are better positioned to deploy and to connect to renewable generation, realizing the critical role, and value, of their existing distribution and substation assets.
- Research results identify best practices and opportunities for grid modernization while helping justify needed investments.
- Evaluating new applications and hardware will support members' planning considerations and help avoid investment mistakes.
- Preparing for increased penetration levels and offering new ways to connect and use renewable generation can help members retain leadership in the production and delivery of electric energy.

Current Year Activities

- Develop screening tools, criteria, and guidelines for increasing penetration of renewable generation in existing radial and network distribution, as well as future circuit functional requirements.
- Plan and conduct a member's workshop to share current practices and identify future need for planning and integration tools, as well as assessment of advanced circuits design concepts.
- Survey current AMI deployment with distributed generation and explore ways that advanced metering systems help enable, integration, including a comparison of current and expected future performance.
- Identify and provide application and design data for promising direct current use of photovoltaic energy by end users.
- Develop performance criteria, design, test, and set up laboratory test stand to evaluate available inertie hardware, systems, and configurations.

Estimated 2010 Program Funding

\$1.3M

Program Manager

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Summary of Projects

PS174A Integrating Renewables into Distribution (067431)

Project Set Description

This project set focuses on the distribution system's readiness for high penetration of renewable and distributed generation. The first project is related to incremental increases of distributed generation into today's existing distribution, both radial and network. The second project will assess future distribution system designs and related options for integrating anticipated high penetration of renewable and distributed generation. There are aligned with EPRI's Green Circuits, Smart Grid and Intelligrid programs.

Project Number	Project Title	Description
P174.001	Planning and Design for Integrating Renewables into Existing Distribution	Continues 2009 activities engaging utility personnel in applying screening tools, developing planning and application guidelines.
P174.002	Assessing Future Distribution Options for Integration of Distributed Renewable Generation	The project will assess future distribution options for integration of distributed renewable generation.

P174.001 Planning and Design for Integrating Renewables into Existing Distribution (067492)

Key Research Question

Existing radial and network distribution systems are not designed for a significant penetration of distributed generation. The key issues are lineman and public safety, circuit protection, voltage control, and reliability. Circuit limits on the penetration of distributed generation are expected due to output variability and two-way power flows. Specific problems to be addressed are planning and design for adaptability of relays, interactive voltage control, fault detection, phase-to-ground overvoltage and islanding detection, and service restoration methods.

Approach

This project looks at making incremental renewable generation additions in today's existing radial and network distribution systems without sacrificing safety, reliability, or effectiveness. Starting with prior EPRI R&D, this project focuses on changes needed in planning, design, and operating criteria for high penetration of distributed and variable generation. It will provide guidelines, impact analysis, and assessment methods to determine the limits and analyze the expansion options and potential system value.

Impact

- Enhance ability to conduct resource planning, improve on interconnection screening and requirements, and maintain circuit performance and reliability.
- Gain access to and exchange up-to-date information. Share best practices, state-of-the-art developments, and related information from other distribution companies.
- Benefit from collaborative R&D activities and sharing applications, experiences, lessons learned, and solutions related to integrating distributed renewable generation.
- Address current renewable power generation issues via analytical studies, developing planning methods, applying screening tools, and evaluating specific interconnection case studies.

How to Apply Results

Utilities faced with planning or integrating new renewable generation will utilize the results of this project to ensure that the full implications of safety, reliability, and electrical performance are considered. Findings can be used to work with developers wanting to connect green buildings, construct zero-energy homes, and implement sustainable community strategies.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Guideline on applications of adaptive relaying to accommodate high penetration: Technical update includes sample case studies and provides guidelines on applying adaptive relaying to accommodate high penetration of DG.	11/30/10	Technical Update
Planning methodology to determine practical circuit limits for distributed generation: Technical report presents planning fundamentals to help users determine the practical substation and circuit limits for DG integration in distribution systems.	12/31/10	Technical Report
Guideline on voltage control strategies for high penetration of distributed generation: Technical update includes sample case studies and provides guidelines on voltage control strategies for high penetration of DG.	12/31/10	Technical Update

P174.002 Accessing Future Distribution Options for Integration of Distributed Renewable Generation (067493)

Key Research Question

Decisions on replacing or upgrading aging distribution systems will require considering the potential for high levels of distributed renewable generation. Utilities would like to plan for and build in capability to support higher penetration levels of distributed renewable generation while maintaining safety, protection, and reliability. A key issue this project will address is new distribution system designs that will allow greater penetration of distributed resources.

Approach

This project addresses future distribution options for planning, design, and operation with new integration devices, advanced distribution system configurations, and practices capable of supporting wide-scale integration of renewable generation. It also assesses new concepts, methods, and tools along with the related cost and timing for accommodating high levels of variable distributed generation.

Impact

- Knowledge, perspective, and new ideas about what future distribution systems with significant levels of distributed generation, related communication, and automation will need to look like.
- Collaboration with other members to develop criteria, apply planning methods, and share design concepts for the distribution systems of the future.
- Results from analytical studies, modeling and simulations, case studies and demonstration of new distribution designs with high penetration of renewable generation.

How to Apply Results

The criteria, configurations, and designs for accommodating high levels of renewable generation will help distribution system planners think through and incorporate needed changes in system plans. Distribution engineers and operators will use results that describe future options to frame recommendations and consider new operating procedures that will be required to accommodate high penetration of distributed resources.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
<p>Report on circuit functionality and requirements for future grid integration: Required new functionalities for future distribution systems to incorporate high penetration of distributed generation will be reported. Topics include the role of ADA, interface with communications architectures, and microgrids. Relative cost and timing for these deployments will also be covered.</p>	12/31/10	Technical Report
<p>Development of Advanced Circuit Guidelines (Initial Chapters for future EPRI Color Book document): Initiate process of developing recommended guidelines for advanced circuits needed to integrate higher levels of renewables and distributed generation, and to evolve into an EPRI Color Book. Proposed initial chapters are:</p> <ul style="list-style-type: none"> • Overview of Impacts on Planning Tools • Communication Infrastructure Needs for Integration of Renewables and DG (in coordination with Intelligrid) • Protection Systems to Integrate Renewables and DG • Voltage and Var Control with Renewables and DG 	12/31/10	Technical Update
<p>Workshop on Advanced Design Concepts for future grid Integration: This workshop will focus on advanced design concepts and options, such as the SCE Avanti circuit, microgrid results from Europe and the United States, and integrating renewables and DG with automation schemes. It will be scheduled in parallel with the workshop in 174.001 on existing circuits and current practices for high penetration of DG.</p>	10/31/10	Workshop, Training, or Conference

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Workshop on Advanced Circuit concepts for Integration of Distributed Generation: This workshop will be a follow-on from 2010 and will address advanced circuit concepts for the integration of distributed generation.	10/31/11	Workshop, Training, or Conference
Assessment of Cases that Demonstrate Deployment of Advanced Distribution Circuits with DG: This will be an update/assessment of actual case studies showing the planning, design and implementation of advanced circuits that demonstrate future configurations and hardware needs for high penetration of DG.	12/31/11	Technical Update

PS174B PV & Metering Integration into Distribution (067432)

Project Set Description

This project set focuses on end-user level, distributed renewable interface technologies. Both grid-tied and direct PV energy-to-appliance applications, as well as related hardware, will be covered. For grid-connected applications, advanced metering systems, inverters, controllers and other related intertie equipment will be evaluated. The direct use of dc from photovoltaic generators into drives, lighting, battery, PHEV and other electronic end uses will be investigated and tested.

Project Number	Project Title	Description
P174.003	Advanced Metering Infrastructure (AMI) Applications for Distributed Renewable Integration	This project continues from 2009, moving from a survey of utility engagement level and requirements assessment to more hands on and field applications. AMI evaluations in the laboratory continues.
P174.004	DC Applications for Direct Use of Distributed Photovoltaic Generation	The project will continue surveying and reporting on PV-DC devices and applications. Where practical laboratory and/or field evaluation will be conducted.
P174.005	Evaluation of Distributed Renewable Grid Interface Systems	Laboratory and field evaluation of distributed renewable grid-interface systems.

P174.003 Advanced Metering Infrastructure (AMI) Applications for Distributed Renewable Integration (067494)

Key Research Question

With deployment of advanced metering infrastructure, many utilities are making a financial investment in AMI technology. Timing is critical for AMI designs to take into account future requirements for integrating distributed resources. Although data capture may not be a problem, integrating data into billing and accounting software can be. To the extent that future PV system designs can employ AMI capabilities, the economics of both will be enhanced.

Approach

AMI devices will be evaluated for use with PV inverter controller systems to determine synergies in functions and capabilities. For example, AMI should be confirmed as net-metering-compatible both functionally and with data acquisition. New data streams from AMI should consider what updates, upgrades, or overhauls will be

needed to existing billing and accounting software. Customer-sited distributed generation (DG) will be considered as part of this process. Interfacing methods will be explored, and where possible tested in the laboratory and demonstrated in the field.

Impact

- Helps members specify AMI systems that will handle future requirements for distributed renewable integration.
- Provides insight in how future AMI and DG will interface with billing and accounting.
- Identifies AMI systems that provide flexibility and functionality for future DG integration.
- Avoids going back and patching later, which would incur otherwise avoidable costs.

How to Apply Results

Using the field experience and lessons learned reported in this program, members can refine plans and adjust implementations in their own AMI deployments. The AMI criteria, new configurations, and future design concepts identified in this R&D program can be incorporated into specifications for major distribution system and customer interface upgrades or new circuits accommodating high levels of renewable generation.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Expanded Web Based Library of AMI Use Case Experiences: This activity provides continued management of a use case and requirements library, with appropriate updates and new case lessons learned. These results will be combined and summarized for easier use by members and to be provided in a straw-man document for future industry standards AMI development activities.	09/30/10	Technical Resource
Field Performance Assessments for AMI used with Renewable Resources: These field performance assessments will be carried out at locations where AMI is being applied with the integration of distributed resources. Attributes of these cases and future needs will be identified.	12/31/10	Technical Update
AMI System Laboratory Evaluations: Lab evaluations will be conducted for selected AMI configurations and architectures based on the interest of participating members.	12/31/10	Technical Update

P174.004 DC Applications for Direct Use of Distributed Photovoltaic Generation (067495)

Key Research Question

Utilities must take proactive technical leadership in advancing new ways to use PV produced electricity at end-use customer sites. Trends toward adding power electronics to improve efficiency in many appliances, adding dc electric energy storage as in PHEV applications, and installing rooftop PV will bring new opportunities for the dc-direct applications.

Approach

This project will conduct scoping studies, define new applications, and develop conceptual designs for integrating PV generation via DC applications, including adjustable-speed drives, lighting, battery storage and plug-in electric hybrid vehicles (PHEVs). Results will be provided via paper studies, hardware demonstration partnerships, and lab evaluations as well as lab and field deployment demonstrations.

Impact

- DC-direct applications can greatly simplify interconnection issues for PV, increase the efficiency of PV systems, and reduce the cost of integration and interconnection.
- By getting ahead of customers in identifying and understanding new applications, members leverage other emerging end-use programs and may identify new business opportunities to provide end-use electric energy.
- Results from laboratory evaluation and field demonstrations will help define integration and performance requirements for these applications.

How to Apply Results

Members with active programs in end-use energy efficiency and demand management can apply these results to extend such programs to include integration of on-site solar power. As deployment of distributed PV becomes more widespread, results from this program will help shape utilities' future roles and identify new business options for end-use energy systems.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Performance assessment and aggregation of Lessons-learned from PV-DC Installations: This technical update will assemble performance information from site demonstrations of PV dc systems in addition to product information and evaluations. Overall knowledge acquired regarding both issues and opportunities for future utility involvement in PV-dc system deployment will be addressed.	12/31/10	Technical Update
Laboratory evaluations of PV-DC devices and applications: Obtain and evaluate PV-DC devices based on member interest and most likely future impacts on electric energy use.	11/15/10	Technical Resource
EPRI Solar Electric Interest Group: Solar Electric Interest Group (SEIG) includes participation in all meetings, webcasts, technical tours and workshops. Results include future plans, findings from site visits, discussions of biomass R&D topics, deployment issues, and project developments, and summary materials from any workshops.	12/31/10	Technical Resource

P174.005 Evaluation of Distributed Renewable Grid Interface Systems (067496)

Key Research Question

Utilities need to take proactive technical leadership in understanding and advancing new grid interface systems for future high penetration of renewable resources. Developing performance criteria, and evaluating and demonstrating new interface hardware and systems, will position members to more effectively work with developers and customers wanting to deploy distributed renewable generation.

Approach

This project looks at system compatibility (immunity, emission and energy performance) profiles, protection settings, communication and control interface, specifications, availability, performance, and the cost of existing inverter systems and other distributed renewable generation grid interface hardware. It will identify new options, including related performance criteria, and will include lab testing and field demonstration of new configurations, systems, and devices with options for the utility's point of common coupling either on the AC or the DC side of the device or inverter. Project efforts are expected to evolve from concepts, prototypes, and first-adaptor applications to industry best practices, guidelines, and proposed standards.

Impact

- Hands-on evaluation of new interface hardware and systems will position members to more effectively deal with interconnection requests.
- Benefit from collaborative evaluation activities and the shared results of field experiences, lessons learned, and solutions related to integrating distributed renewable generation.
- Address current and growing interest in the deployment of distributed renewable power generation, with results on available interface systems and their performance.

How to Apply Results

Utilities faced with planning or integrating new renewable generation will use the results of this project to ensure that the full implications of safety, reliability, and electrical performance are considered. Findings can be used to work with developers wanting to connect green buildings, construct zero-energy homes, and implement sustainable community strategies.

2010 Products

Product Title & Description	Planned Completion Date	Product Type
Develop performance criteria and related test plans for renewable generation interface systems: This project will build on prior grid interface research, performance requirements, and related test protocols in the DER area. It will develop performance criteria for different configurations and point-of-connection and design tests that address current and future utility practices for mating meters, inverters, and related intertie equipment.	12/31/10	Technical Update
Design laboratory test stand, plan performance and compatibility testing: This project will build on prior grid interface test equipment, methods and related test protocols developed by EPRI for DER evaluations. It will develop the needed laboratory test stands as well as plans for performance and compatibility testing, including immunity, emission, and energy performance.	12/31/10	Technical Resource

Future Year Products

Product Title & Description	Planned Completion Date	Product Type
Database resource on interface system configurations, functions and specifications: This project provides a database for comparing different system configurations and functions that could be used for the interface/integration of renewable generation, including meters, inverters and other interconnection equipment.	08/31/11	Technical Resource
Lab evaluation reports of selected grid interface systems: Selected equipment and interface systems will be set up and tested in the lab. Results are available to the manufacturer and project participants. In some cases, testing will be accomplished in the field at host utility sites.	12/31/11	Technical Update